A POSSIBLE LUNAR INFLUENCE UPON THE VELOCITY OF THE WIND AT KIMBERLEY.

(Second Paper.)

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(With one Text-figure.)

In a previous paper under the same title reasons were given for presuming that the moon must exert a certain amount of influence upon the movements of the lower air. Tables were also given showing the variation in the velocity of the wind during the course of the lunar day in general, and also for the moon south and moon north of the equator. From the results of the investigation a mean diurnal range of velocity, attributable to the moon, of 0·2 mile an hour was deduced, but much greater ranges when the observations were separated into sets for moon south and moon north. My opinion at the time was that these ranges were greater than should have been expected *à priori*. In the present discussion, however, the problem has been carried a step further, and even greater ranges are deduced.

We have to do now with the variations in the velocity of the wind when the moon is near perigee. The period covered is nearly twenty-two years, comprising 288 perigees, from April, 1897, to January, 1919—that is to say, it covers some eight years more of time than the first paper did. Perigee was selected partly because some rigid standard of reference was desirable, partly because a somewhat greater effect might be anticipated from the moon's contiguity, and chiefly for reasons to be developed as we proceed.

The tabular numbers in the table have been computed as follows:

Let V_n be the velocity of the wind at any civil hour n;

v_n the mean velocity for the same hour of the same month.

Then $V_n - v_n + 10$ is a quantity to be transferred to its proper hour of the lunar day, the numeral 10 being added in every case in order to obviate the necessity for the use of plus and minus signs. A further convenience is that in the process of taking means of the quantities $V - v + 10$, anything greater than 10 is positive, anything less is negative. The meaning, therefore, of the numbers in the table is that the normal hourly means are supposed to lie upon the straight line $z = 10$, and that the tabular numbers are as deviations from that line. This plan eliminates the possibility of any intrusion of solar or other periodicities—which are especially liable to intrude where such things as perigee are concerned, seeing that at perigee the moon culminates most often in the hours about noon and midnight, and seldom at VI or XVIII. The observations made use of are those for the day upon which perigee occurred, together with the day before and the day after, 864 days in all, necessitating considerably over 20,000 simple subtraction sums. The labour is almost prohibitive.

In the table on p. 146, column 1 indicates the hours of the lunar day, U.M.P. being lunar noon, the mean of the first and twenty-fifth being accounted lunar midnight, or L.M.P.

Column 2 gives the hourly means of the deviations $V - v + 10$ for all the perigee periods as defined above.

Column 3 gives the means of the deviations when the moon near perigee culminates between X and XIV. These we call "noon" culminations.

Column 4 the same for the four hours XXII to II. These we call "midnight" culminations.

Column 5 the same for the remaining hours. These we call "horizon" culminations, since the horizon is nearly the sun's mean position for these hours.

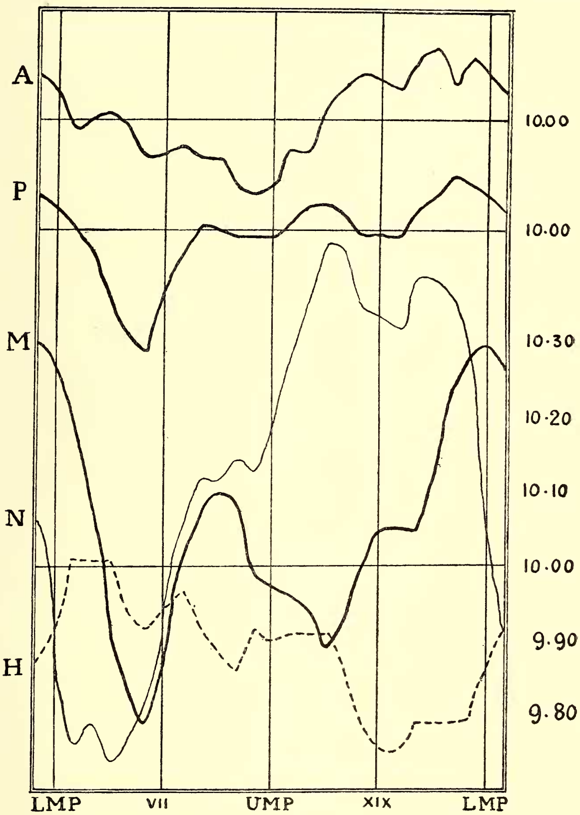
All the tabular numbers have been smoothed in threes by Bloxam's process in order to straighten out minor asperities. Such smoothing is perhaps open to criticism as unnecessary, and, at any rate, it diminishes somewhat the range of the velocity deviations attributable to the moon.

According to column 2 there is one principal maximum and one principal minimum of velocity deviation, the former about XXIII, and the latter near moonrise, with a range of 0·235 mile an hour. Secondary maxima occur at IX and XVI; secondary minima at XII and XX.

It is interesting to compare this perigee range and the range given in the previous paper (which we may regard as the range for the moon's mean distance) with the moon's least and mean distance from the earth. Calling the mean distance unity, the least distance is about 0·933, so that the ratio of the cubes of the distances is as unity is to 0·81. Now the ratio of the ranges of wind velocity for mean and for perigee distances is as unity is to 1·175. or, say, 0·85 to 1: that is, the ratio of the ranges of velocity is very nearly the same as the inverse ratio of the cubes of the moon's distances. And it would be still more nearly the same if we were to take the moon's mean distance for the three days about perigee.

Column 3, derived from 226 noon perigees, and column 4, derived from 269 midnight ones, give two remarkable curves. With minor fluctuations the former has a minimum at IV and a maximum at XVI, with a range of 0·7 mile an hour; whereas the latter has definite double maxima and minima (like a diurnal atmospheric pressure curve) at X and L.M.P. and at VI and XVI, with a whole range of 0·5 mile an hour. Column 5 gives a relatively featureless curve, excepting that it vibrates practically in opposite phases to that of column 3, with a range of 0·25 mile an hour. These are large ranges, but they go to confirm those previously found. The mean values at the foot of the columns are very curious, and possibly significant.

The tabular numbers are shown diagrammatically in the figure, together



Wind-deviation curves.

with the curve for all the observations described in the previous paper. All the curves have something in common, and nearly every turning-point on any one curve has its corresponding analogy on the others. A complete explanation of them all is not yet to be attempted; but a more or less tentative and partial one may be hazarded for some outstanding features. For example, there are differences between the noon, midnight and horizon curves which appear to arise largely, if not entirely, from the diurnal variation of wind direction. This diurnal variation of direction has been

Table Showing the Variation of Wind Velocity in Miles an Hour during the Course of the Lunar Day at Perigee.

Hour.	Mean perigee.	Noon perigee.	Midnight perigee.	Horizon perigee.
L.M.P.	10·024	9·915	10·265	9·916
II	10·001	9·766	10·185	10·012
III	9·975	9·783	10·089	10·009
IV	9·910	9·735	9·918	10·011
V	9·862	9·759	9 844	9·939
VI	9·843	9·804	9·780	9·912
VII	9·907	9·913	9·868	9·932
VIII	9·972	10·032	9 996	9·965
IX	10·007	10·114	10·069	9·917
X	10·002	10·115	10·098	9·881
XI	9·995	10·143	10·080	9·861
XII	9·994	10·125	9·989	9 917
U.M.P.	9·995	10·179	9·974	9·896
XIV	10·016	10·252	9·963	9·909
XV	10·039	10·358	9·945	9·912
XVI	10·040	10·431	9·891	9·910
XVII	10·026	10·426	9·927	9·856
XVIII	9·995	10·346	9·995	9·782
XIX	9·995	10·330	10·045	9·754
XX	9·992	10 317	10·049	9·753
XXI	10·025	10·385	10·047	9·784
XXII	10·048	10 386	10·122	9·781
XXIII	10·078	10·359	10·236	9·786
XXIV	10·067	10·268	10·282	9·787
L.M.P.	10·050	10·056	10·300	9·863
Mean	9·994	10·132	10 036	9·882
Range	·235	·696	·502	·259
No.	864	226	269	369

described in a preliminary way some years ago (J. R. Sutton, "The Winds of Kimberley," 'Trans. Phil. Soc. S.A.,' 1900). Generally speaking, we may say that the normal resultant winds of Kimberley have northerly components from sunrise to sunset, and southerly ones during the night; westerly components from about IX to XX, and easterly ones from XX to IX. Thus when the moon (being north of Kimberley) near perigee culminates at noon, the winds of Kimberley during the day are moving normally down the gradients of pressure set up by the lunar tide in the air, thus augmenting their speeds, whereas during the night they are moving up the gradients and thus diminishing their speeds. A similar sort of explanation applies to the "horizon" curve, and to a good portion of the "midnight" curve; but it gives no adequate reason for the minimum near moonrise common to all the curves, and which is probably of a more general character. Thus the curves shown in the diagram are largely due to the superimposition of the lunar air tide upon the diurnal variation of wind direction.

The acceptance of this explanation would demand that the velocity deviation curves of no two places even on the same circle of latitude would be quite alike, as the lunar air tide (to which they are in great part subject) is. Even so the deviations of velocity cannot be regarded as mere surface phenomena, but rather as the outcome of conditions common to the whole depth of the atmosphere.

In a later paper I hope to discuss the velocity deviations for the moon in apogee. My wife, as usual, has checked off the averages: without her help the investigation could not have been undertaken.

In the diagram A is the mean curve for all the observations used in the previous paper; P, M, N, H are the mean, "midnight," "noon," and "horizon" perigee curves of columns 2, 4, 3 and 5 respectively.